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Managing Water in the West

CALSIM II San Joaquin River Water Quality Module

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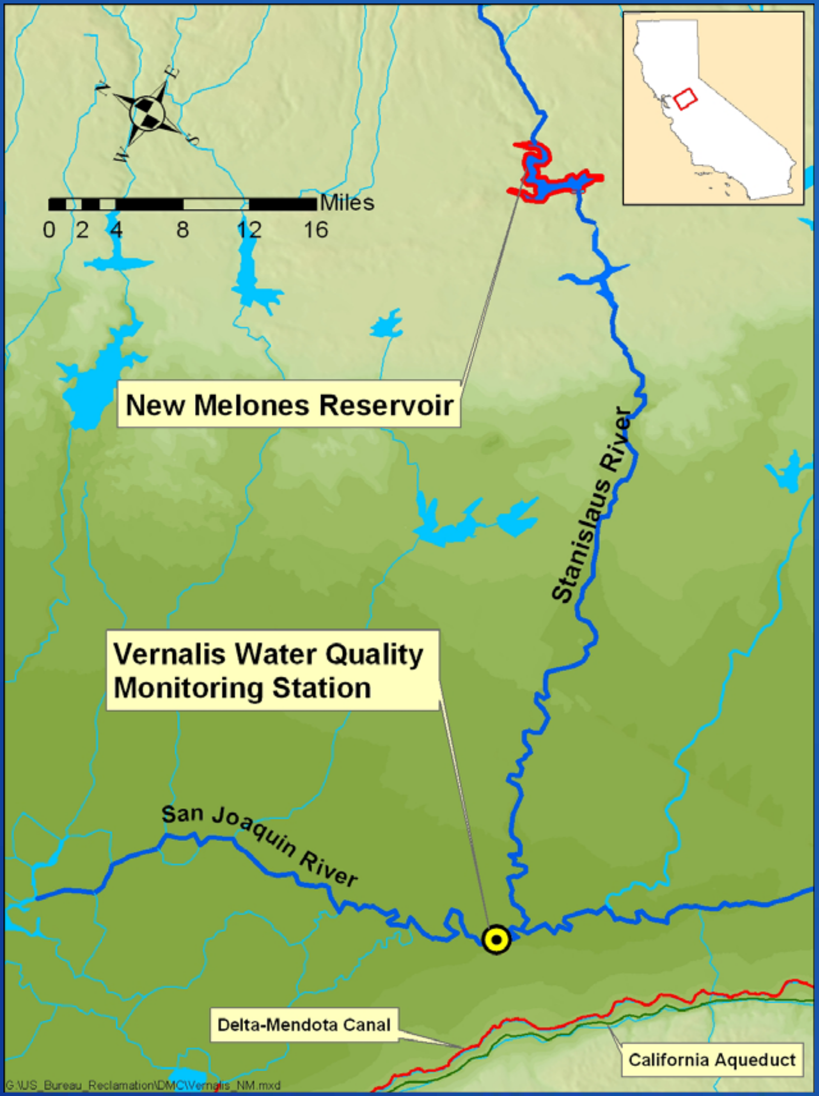
U.S. Department of the Interior
Bureau of Reclamation

Water Quality Module Presentation Outline

- Background on San Joaquin River water quality objectives
- Existing CALSIM II approach and potential limitation for future applications
- Introduction to the new water quality module
- Current and future development

San Joaquin River Water Quality Objectives

- EC objectives at Vernalis
- Objectives met by release from New Melones Reservoir



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Existing CALSIM II Approach to Estimate San Joaquin River Water Quality

- Original Kratzer equation (Pre-CALSIM II)
  - Estimating monthly average EC at Maze Road bridge
    - Relate EC with total flow at Maze
    - Exponential EC-flow relationship
  - Regression last calibrated in 1990
- Existing CALSIM II approach
  - Maze EC
    - Explicit EC for Westside returns
    - Modified Kratzer eq. for relating EC with remaining flow at Maze
  - Vernalis EC estimated by salt balance
    - Estimated Maze EC
    - Explicit EC for inflows between Maze and Vernalis

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Existing CALSIM II Approach to Estimate San Joaquin River Water Quality

- Potential limitations for future applications
  - Outdated calibration
  - Inflexible in water quality simulation

New Water Quality Module

- Future and application oriented approach
- Primary Objectives
  - Improve the accuracy of Maze EC estimates
  - Increase the flexibility of water quality simulation
  - Increase the model consistency and integration
- Secondary Objectives [technical specifications]
  - Modular approach
  - Model compatibility with DSM2-SJR
  - Consistent protocol for data communication

New Water Quality Module

- Staged development through multiple projects and collaboration
  - CALSIM II Link-Node Approach (2003)
  - CALSIM II San Joaquin River Water Quality Module (2003 – 2004)
  - Review by Dan Steiner and subsequent revision (2004)
  - Review by Reclamation's Central Valley Operations Office and subsequent revision (2004)
  - Common Assumptions for hydrology extension (ongoing 2005 -)
  - Improvement above Lander Avenue (ongoing 2005 -)

Resulting Model Under Peer Review

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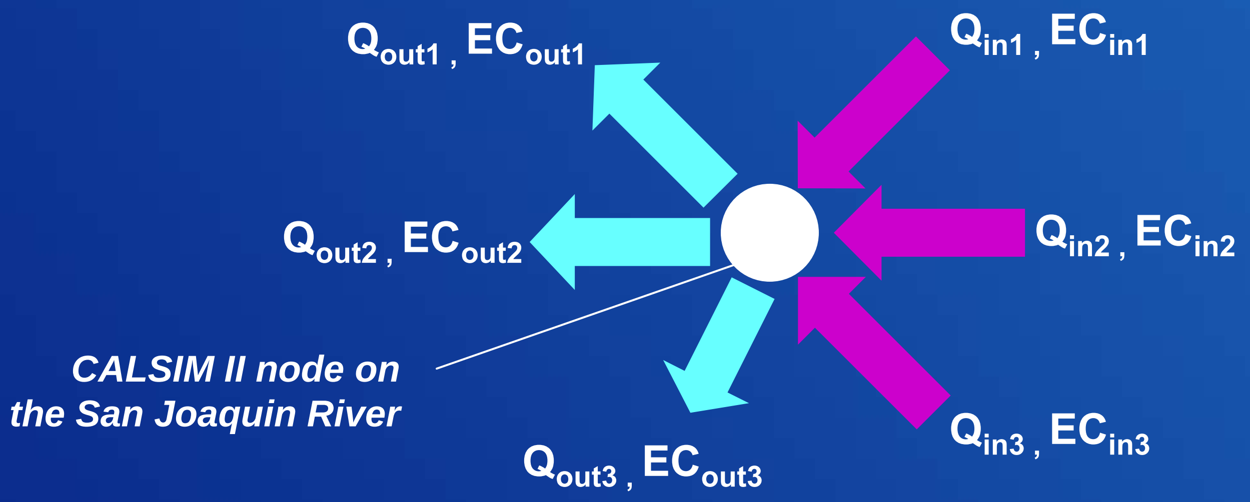
New Water Quality Module

- Approach
- Calibration and Results
- Simulated Operations
- Summary

Mass Balance in Flow and Salt

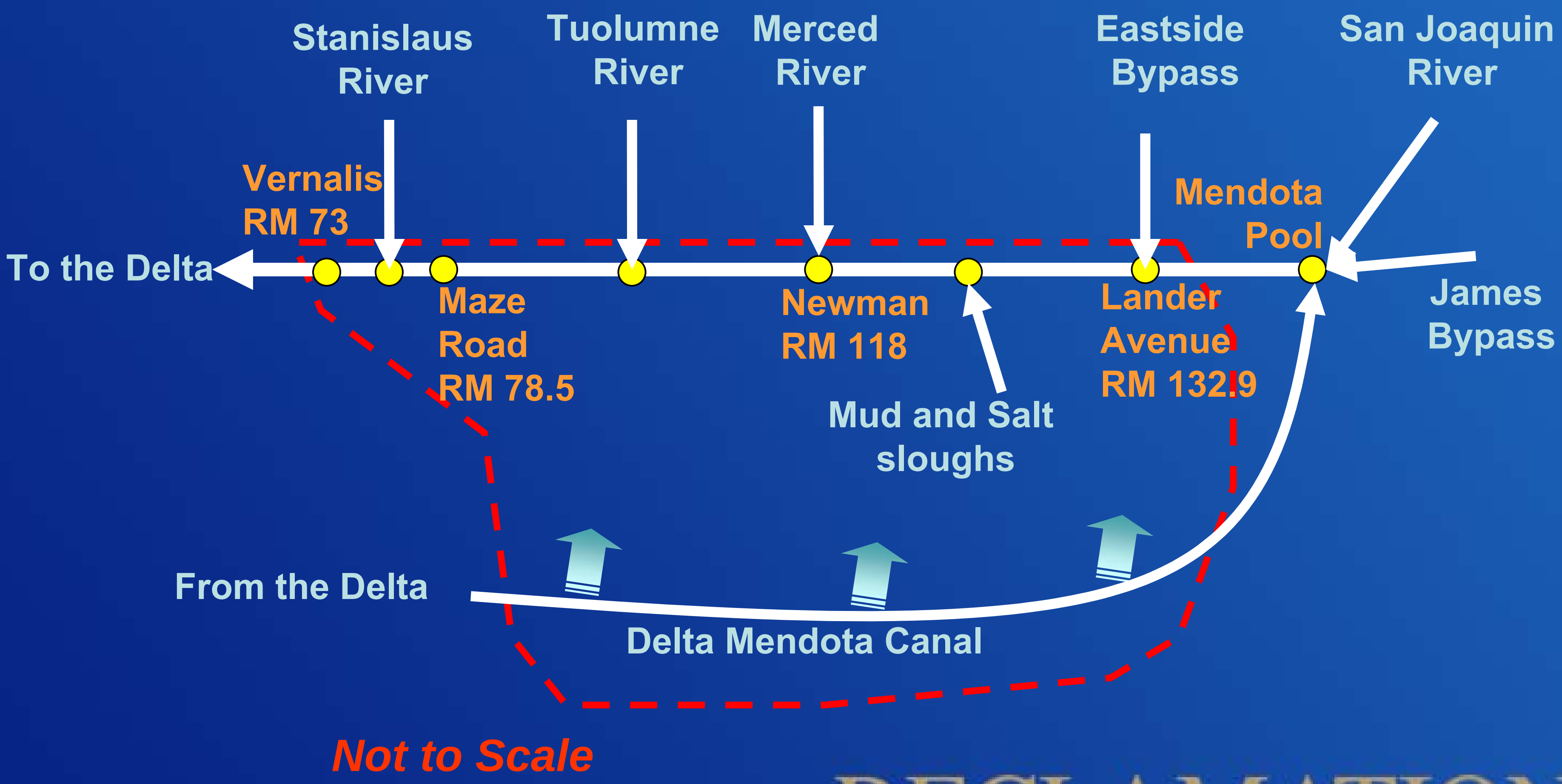


Flow Balance: $\Sigma\, Q_{in} = \Sigma\, Q_{out}$

Salt Balance: $EC_{out} = \Sigma\, (EC_{in} * Q_{in}) / \Sigma\, Q_{out}$

Performed on a monthly basis

Scope of Water Quality Module



Two-stage Disaggregation

CALSIM II
Flows into SJR

→ **Flow Disaggregation** → **Salt Disaggregation**

Grouped by
- Geographic region
- Contract type
- Others

Deliveries
- Source
- Location
- Quantity

Returns
- Source
- Location
- Quantity

Quality per
- Source
- Location

Significant data gaps and calibration concerns …

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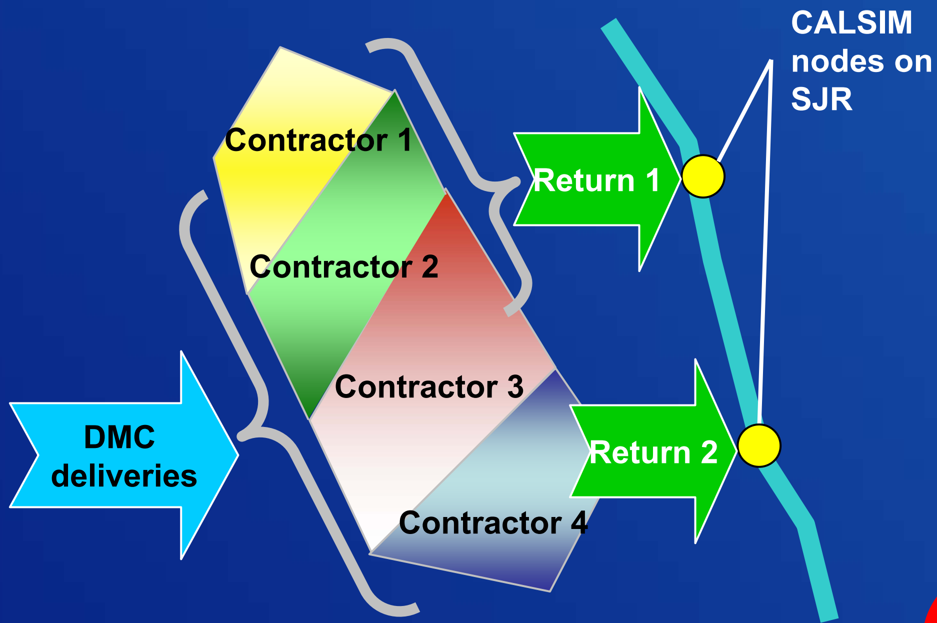
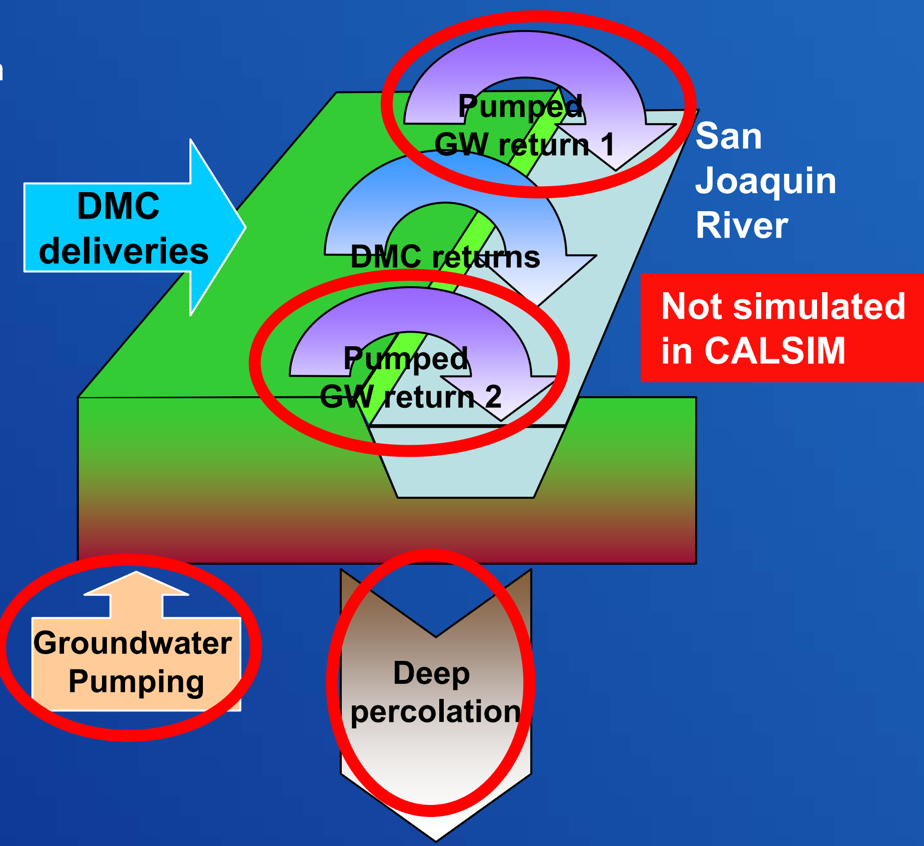
Example of Flow Disaggregation

In Current CALSIM



Reality of Contractor 3



New Water Quality Module

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Calibration Strategy on Flow and EC

- Establish a systematic approach
  - Easy accommodation of new data and model improvement
- Use the best available information
  - Historical records/reports
  - Other model information
  - Individual investigation/personal knowledge
  - Original CALSIM II data
- Allow the use of residual terms

Assumptions on Flow Disaggregation

CALSIM II Variables	Westside Drainage Variables	References for Achieving Mass Balance		
		Location	Quantity	Allocation
Accretion	= S Tile Drainage + S Groundwater base flow + Local creek inflow	SJRIO DSM2-SJR GIS	SJRIO DSM2-SJR Forced balance	
Westside return	= S Westside groundwater returns + Westside surface water returns	SJRIO CALSIM & WESTSIM	SJRIO Forced balance	
Depletion	= Groundwater seepage loss	GIS	CALSIM II	
Non-project diversion	= S Non-project diversion	SJRIO	CALSIM II	SJRIO
Non-project return	= S Non-project return	SJRIO	CALSIM II	SJRIO

CALSIM II controls water balance!

Results of Flow Disaggregation

- CALSIM II dictates flow balance
- Residual terms
  - Local creek inflows
  - Westside surface water returns
  - Results
    - Rare occurrences of small negative flow
- Overall good results

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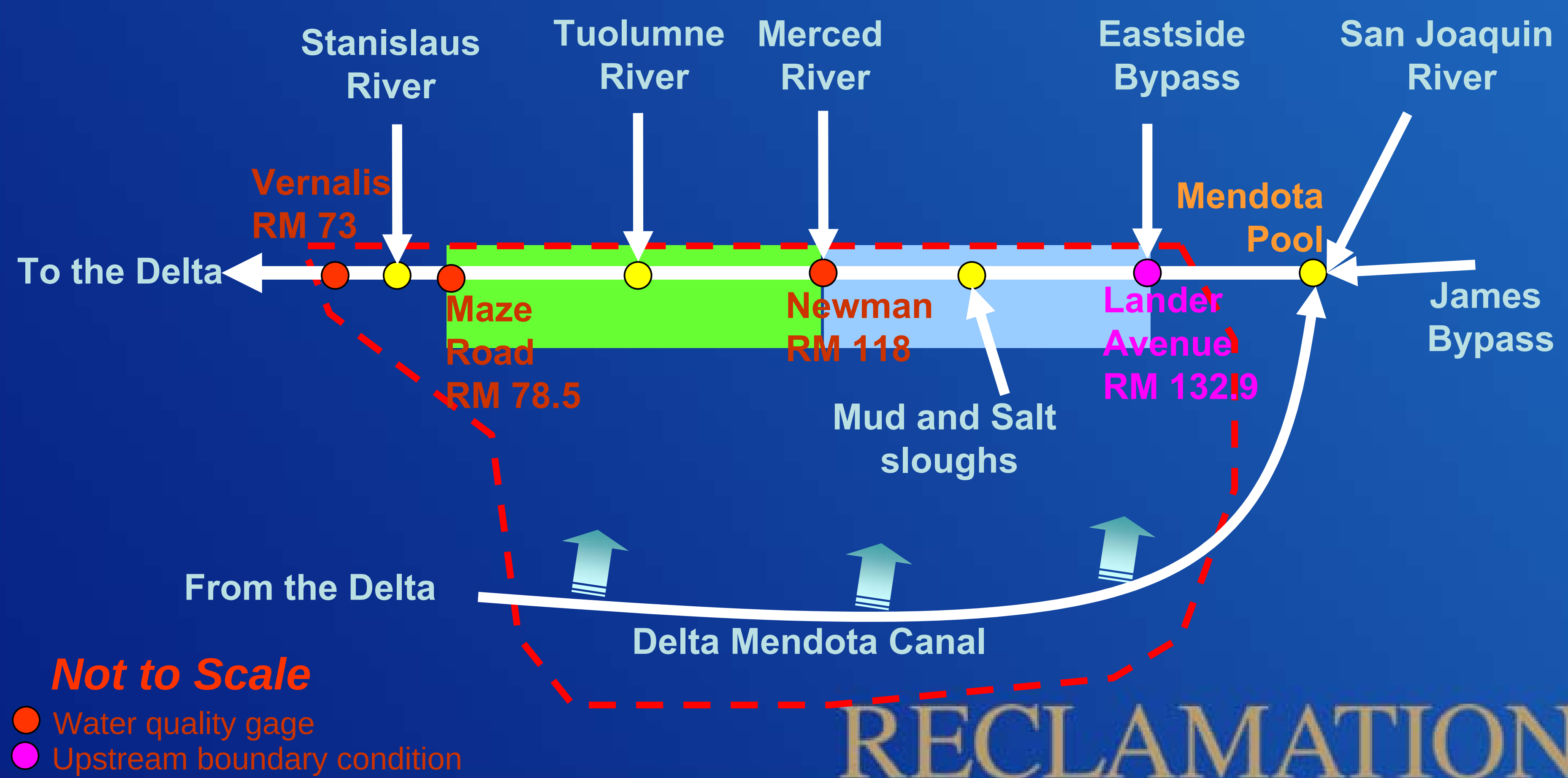
Assumptions on Water Quality

Flow Types	Sources of EC Input
Non-Local Creek Flows	
Tributaries	
Grassland Bypass	Grassland Bypass Project Monitoring Data (Oct 97 to Sep 03)
Mud/Salt Slough base flow	Grassland Bypass Project Monitoring Data (Oct 97 to Sep 03)
VAMP flows from Exchange Contractors	TMDL Report (CVRWQCB 2002a)
San Joaquin River at Lander Avenue	1999 to 2004 gage record
Merced River near Stevinson	1999 to 2004 gage record
Tuolumne River near Modesto	1999 to 2004 gage record
Stanislaus accretions	CALSIM II (September 30, 2002)
Eastside Returns	
From Modesto irrigation districts	CALSIM II (September 30, 2002)
From Tuolumne irrigation districts	CALSIM II (September 30, 2002)
Westside Returns	
From pumped groundwater usage	SJRIO (2003 version)
Through Mud/Salt Slough:	
Exchange Contractors returns	Monthly maximums from 2000 to 2003 observations
Refuge Level 2 returns	WETMANSIM-031604-ver01.00 (Flow-weighted averages of 10 districts)
Other DMC water usage returns	SJRIO (2003 version)
Non-Project Returns	SJRIO (2003 version)
Within Accretions	
Tile drainage	SJRIO (2003 version)
Base flow	SJRIO (2003 version)
Local Creek Inflows	***Not assigned!***
	Residual term: Salt Load Residual

Separating flow and salt residual terms

Calibration Reaches

- Excluding effects of New Melones operation
- Recent gage records at Newman and Maze



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Summary of Water Quality Calibration

- Residual term: Salt Load Residual
  - Assumptions:
    - Salt load residual = theoretical gage load – estimated upstream load
    - Salt load residual allocation:
      - Newman calibration: Lander Avenue and Newman
      - Maze calibration: Tuolumne River confluence and Maze
  - Results:
    - Simulated operation is reasonable.

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New Water Quality Module

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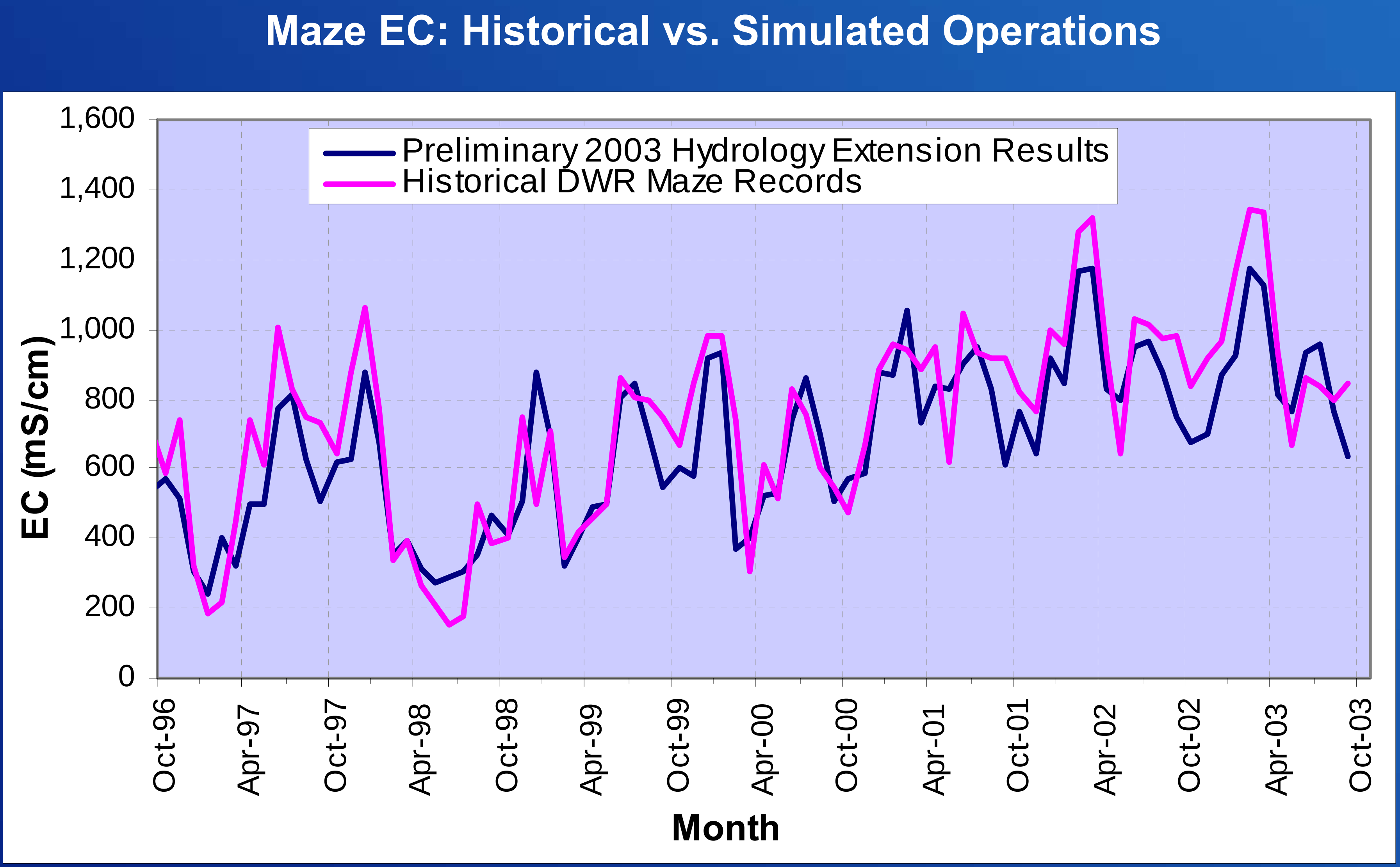
Simulated Operations



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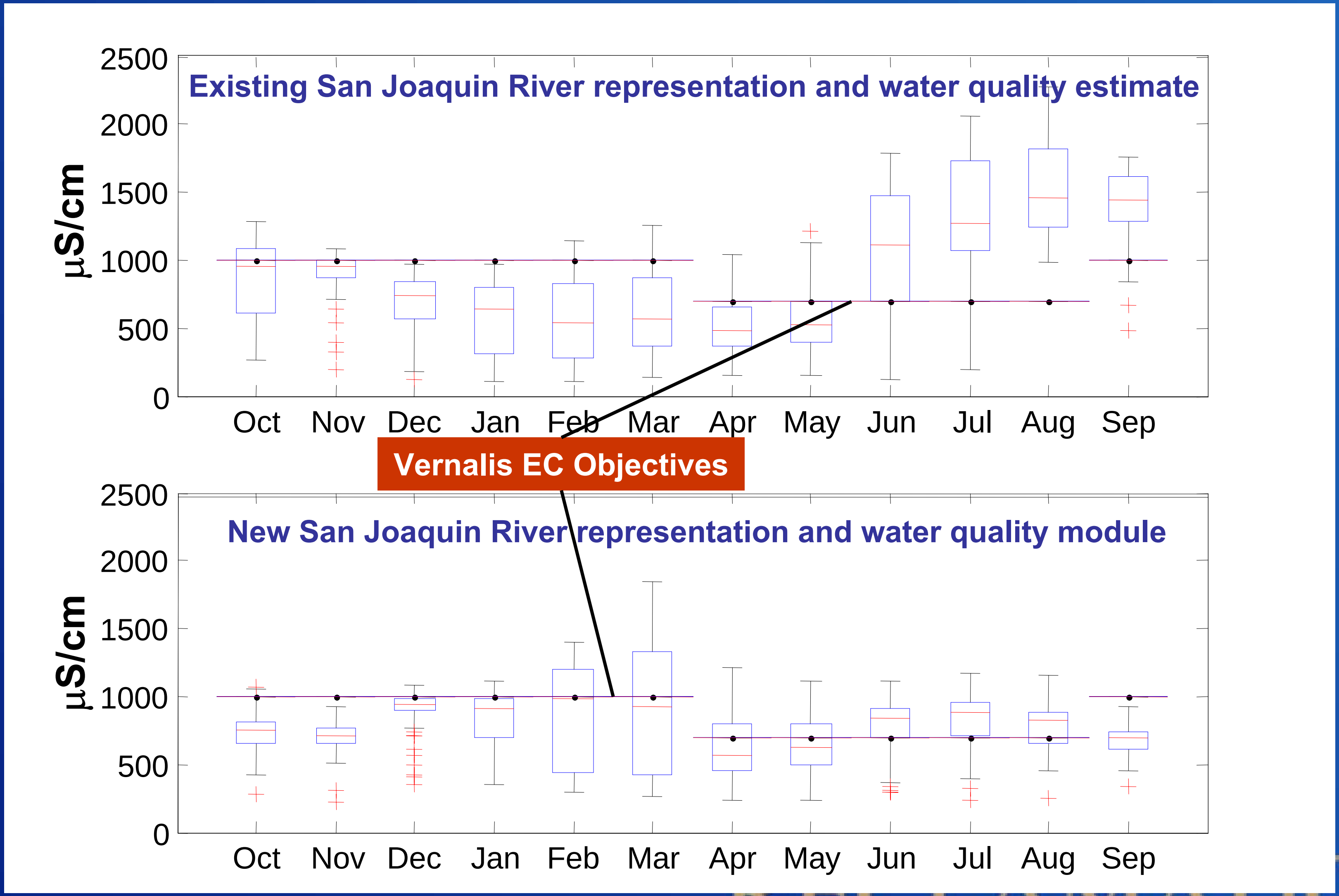
Simulated Operations

Maze EC: Simulated values



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Findings from Simulated Operations

- Regulatory and practice changes in San Joaquin River Valley
  - Focus on recent records
- Linkage between operation and water quality
  - Concurrent improvement

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Summary of Water Quality Module

- Staged development replaced the static water quality estimate
  - Update the estimator
  - Provide additional flexibility
- Disaggregation
  - Significant data gaps
- Calibration
  - Maze EC
  - Focusing on recent records
  - Use of best available information and residual terms
  - Systematic approach allowing future updates

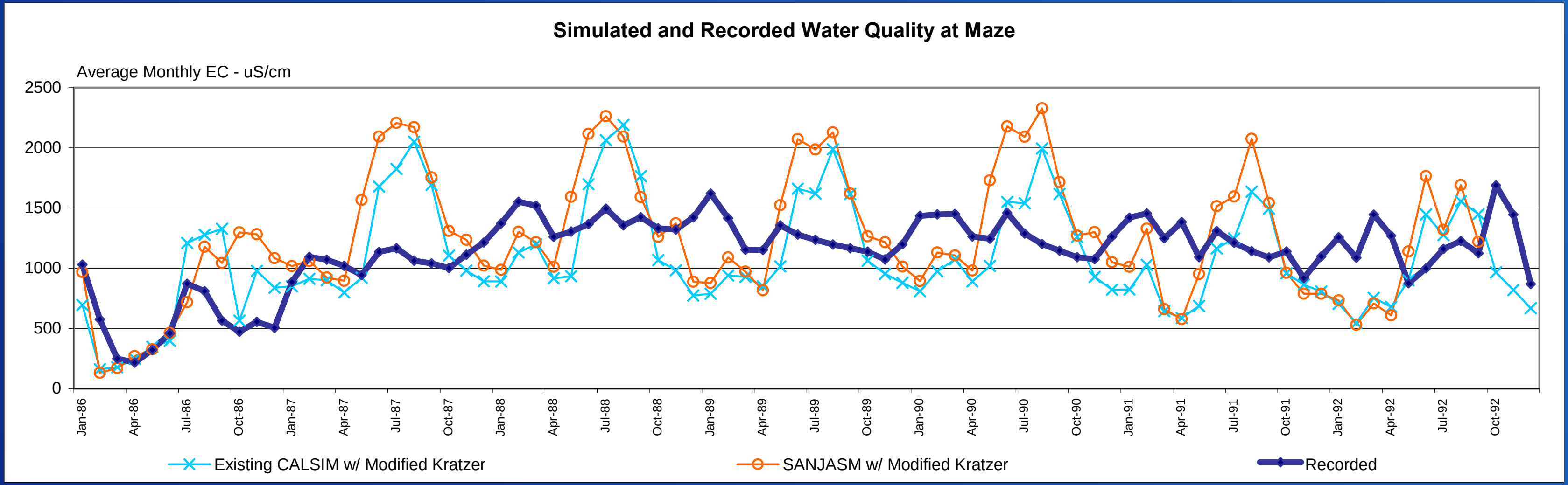
Next Steps for Water Quality Module

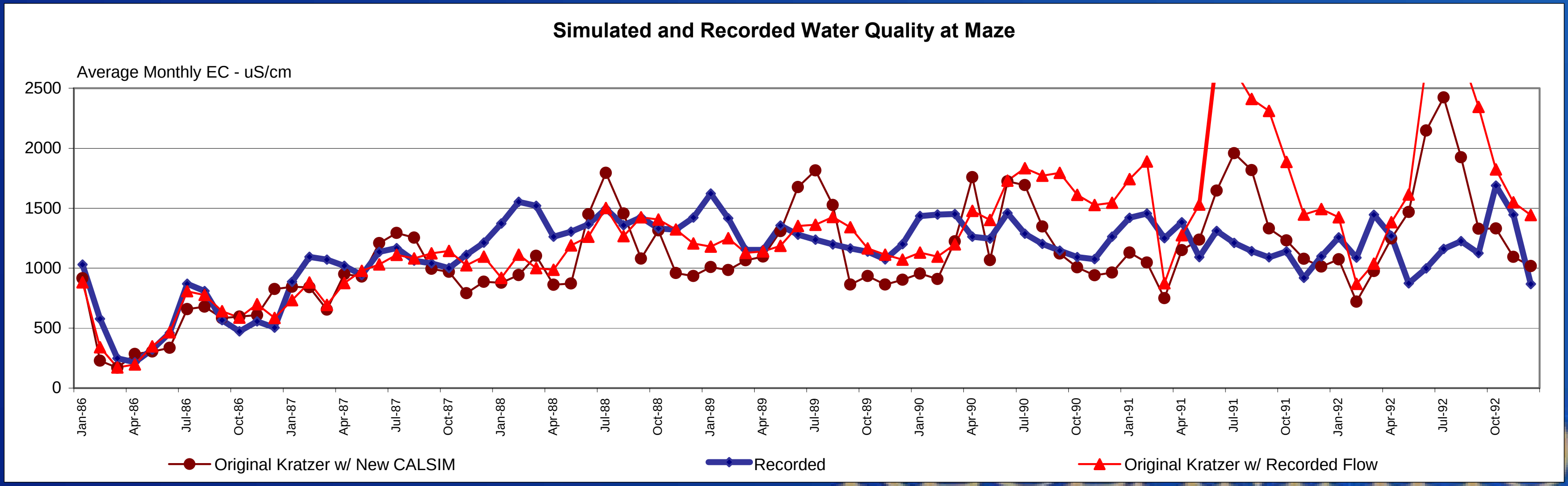
- Ongoing development for Water Quality Module
  - Improvements on resolution upstream of Lander Avenue
  - Hydrologic and water quality data extension
- More discussions in the next session

Thank You

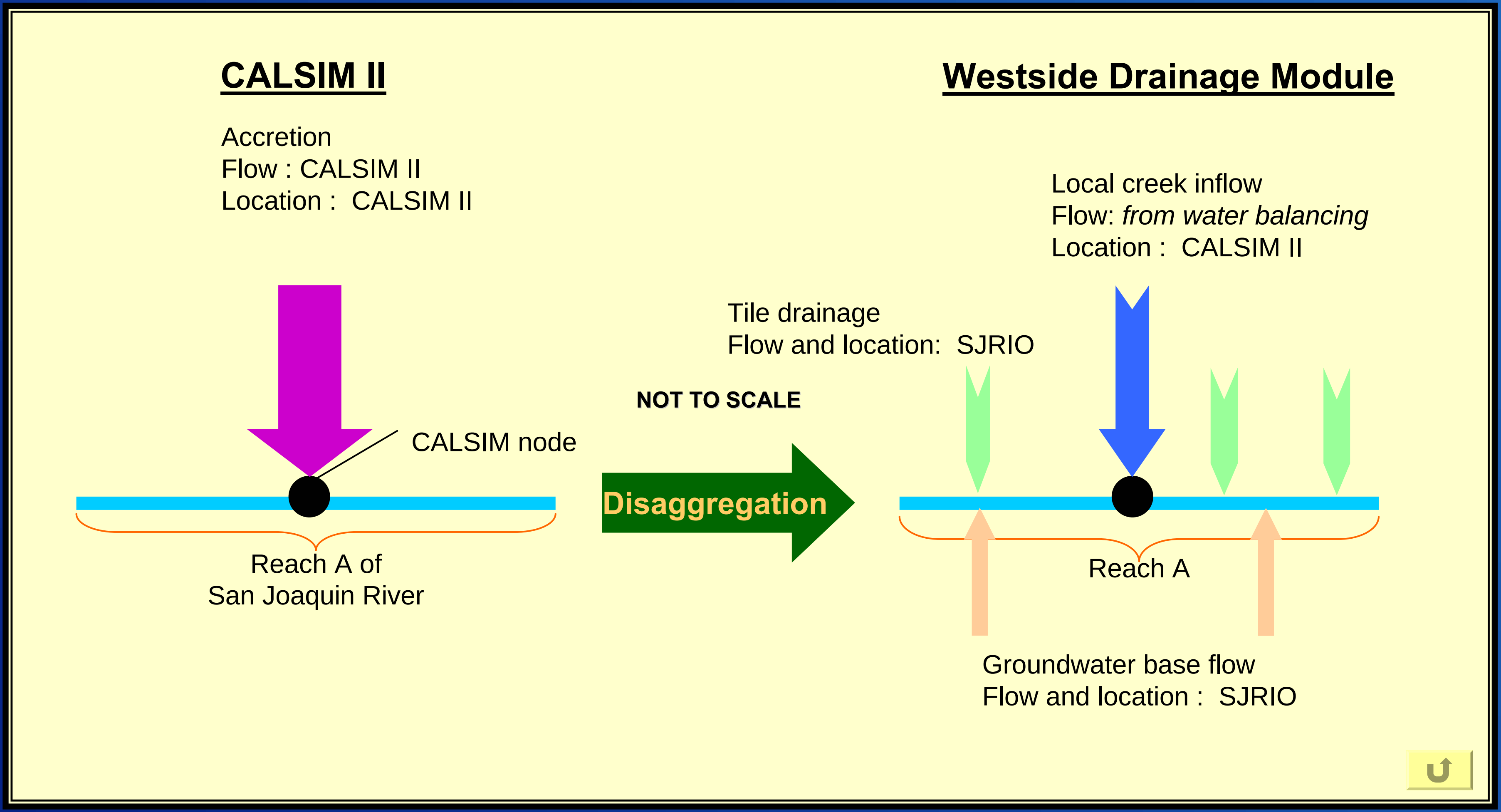
Supplemental Slides (Hyperlinked)

Previous Simulation Estimates of San Joaquin River Water Quality

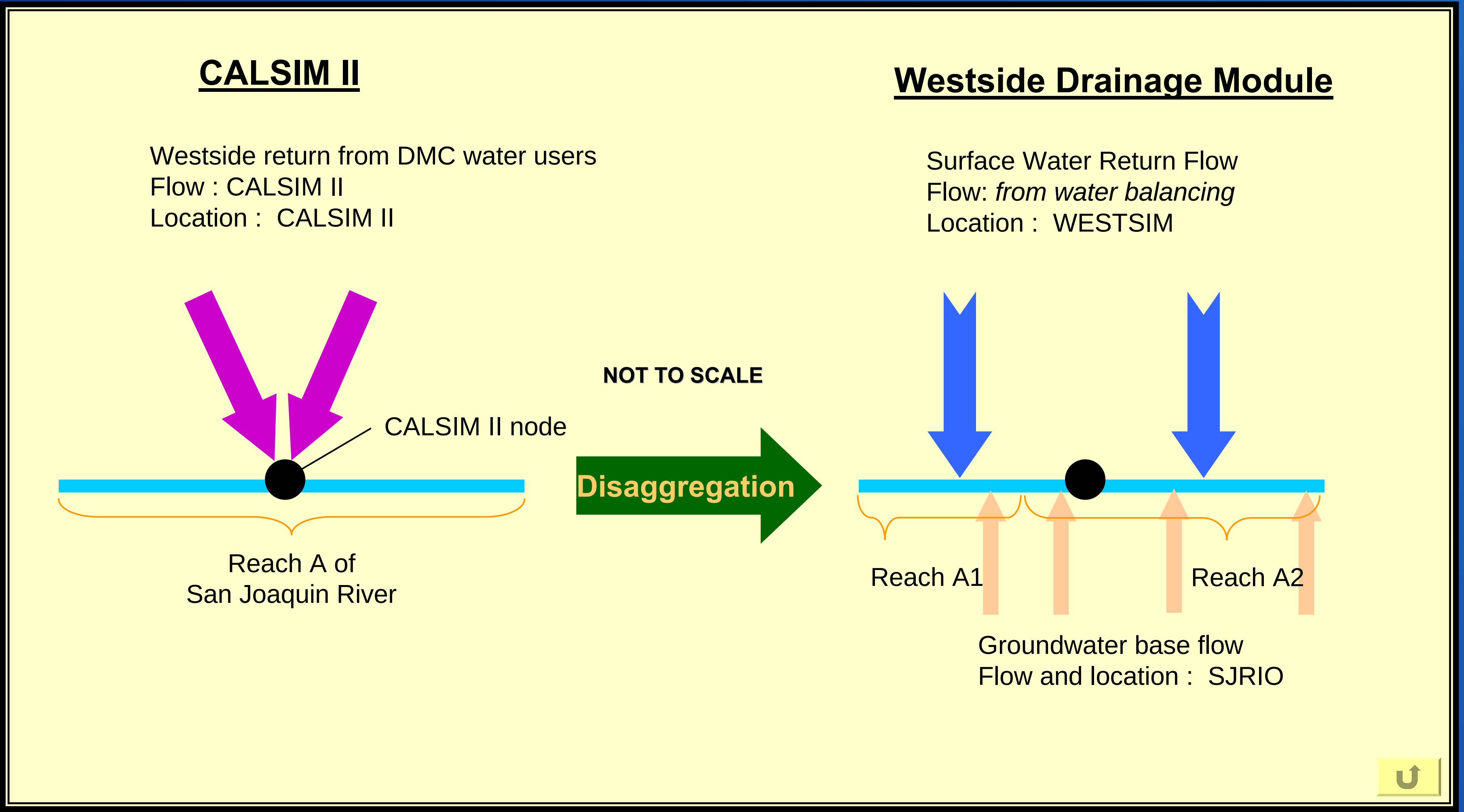




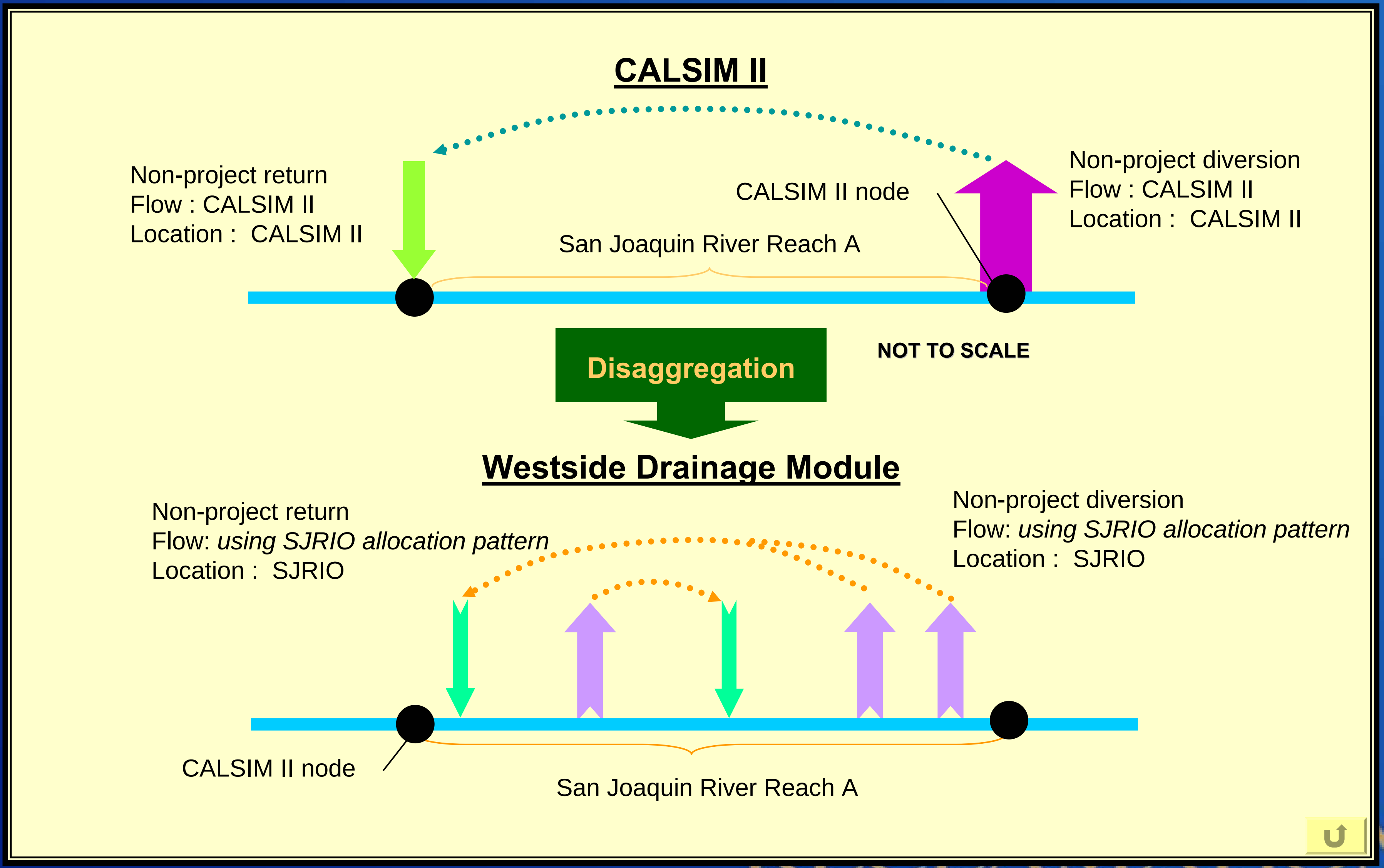
Flow Disaggregation:
Accretion



Flow Disaggregation
Westside returns from DMC water users



Flow Disaggregation
Non-project diversions and returns



Water Quality Parameters

SJRIO Inputs

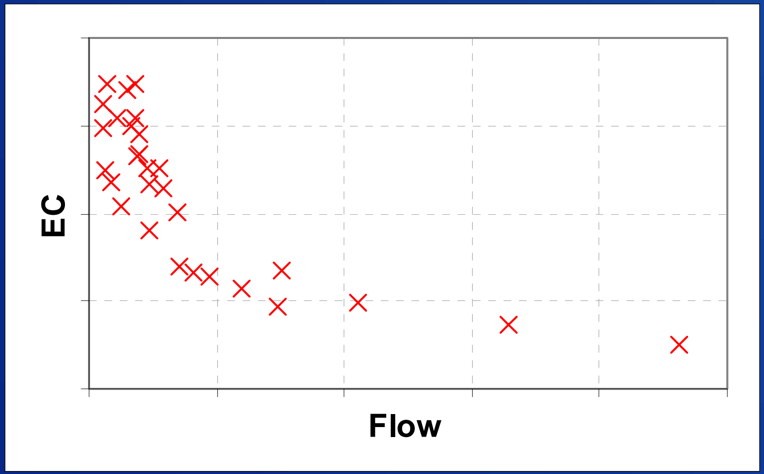
- **Year-type SJRIO water quality inputs were applied to Westside flows based on timing, flow types, and location.**

SJRIO Flow Types	SJRIO Description	Westside Flows in Water Quality Module
SUB	Subsurface agricultural drainage	Tile drainage
GW	Groundwater accretion/depletion	Groundwater base flow
SRF	Surface agricultural discharge	•Westside returns from using groundwater •Westside returns from using DMC water •Non-project return (Assuming waters from different sources are mixed before irrigation)

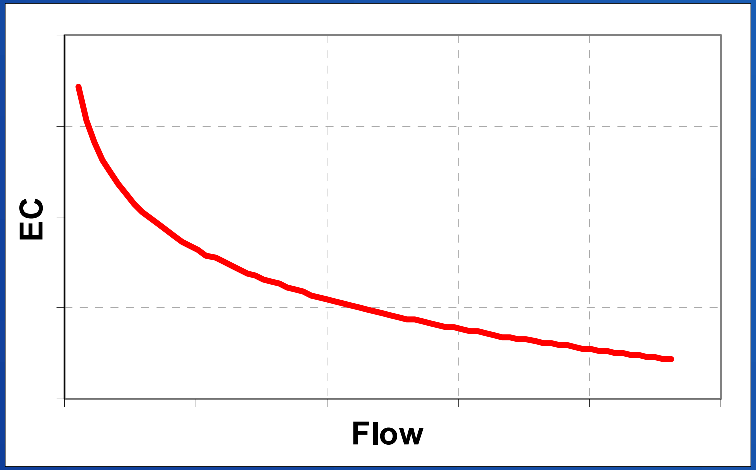
Detailed Process of Calibration 2

1. At the downstream end of a calibration reach, use historical gage records to determine the best fit regression equation to represent the historical EC-flow relationship at the gage.

EC-flow relationship of historical gage records



Best fit regression equation



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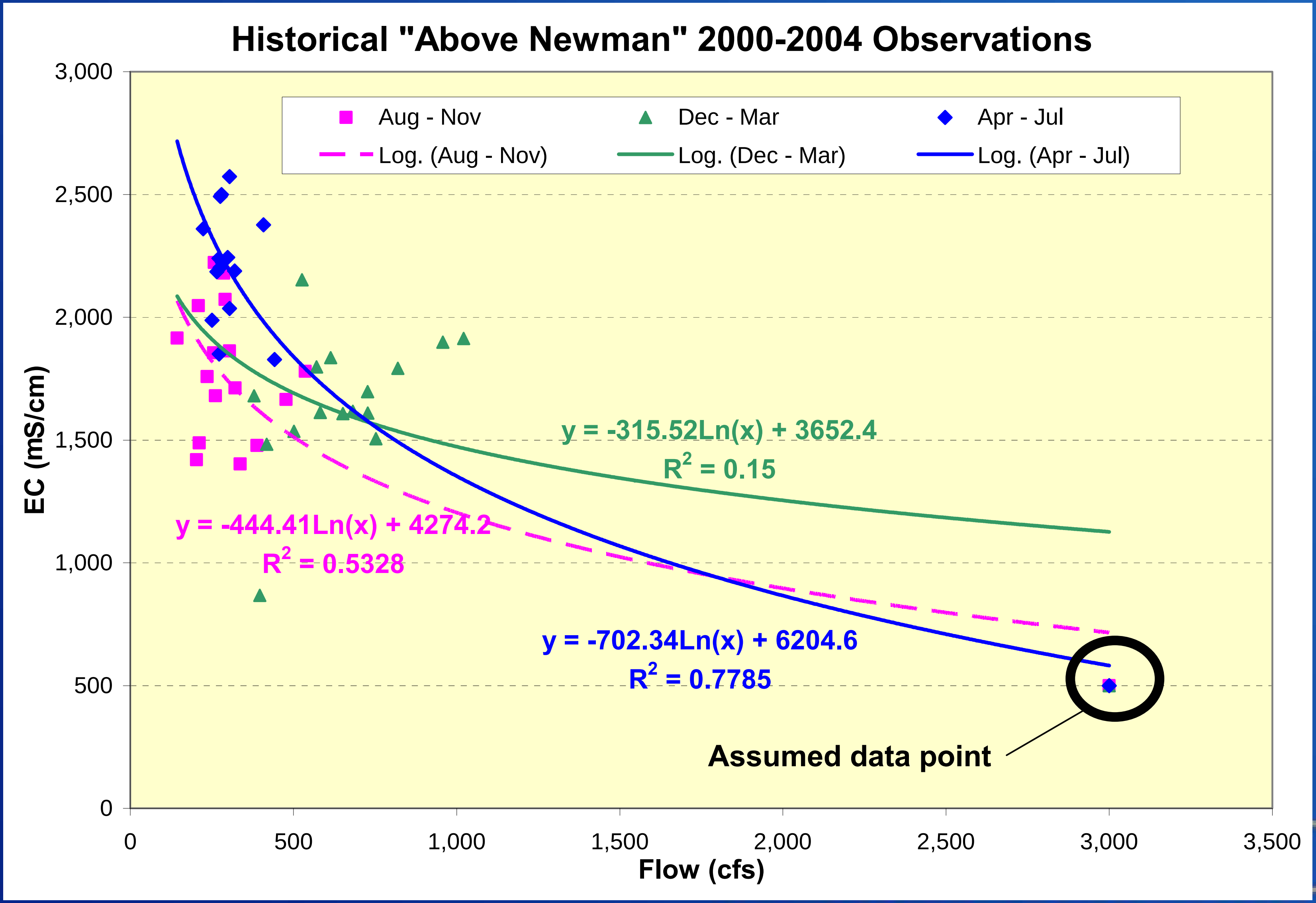
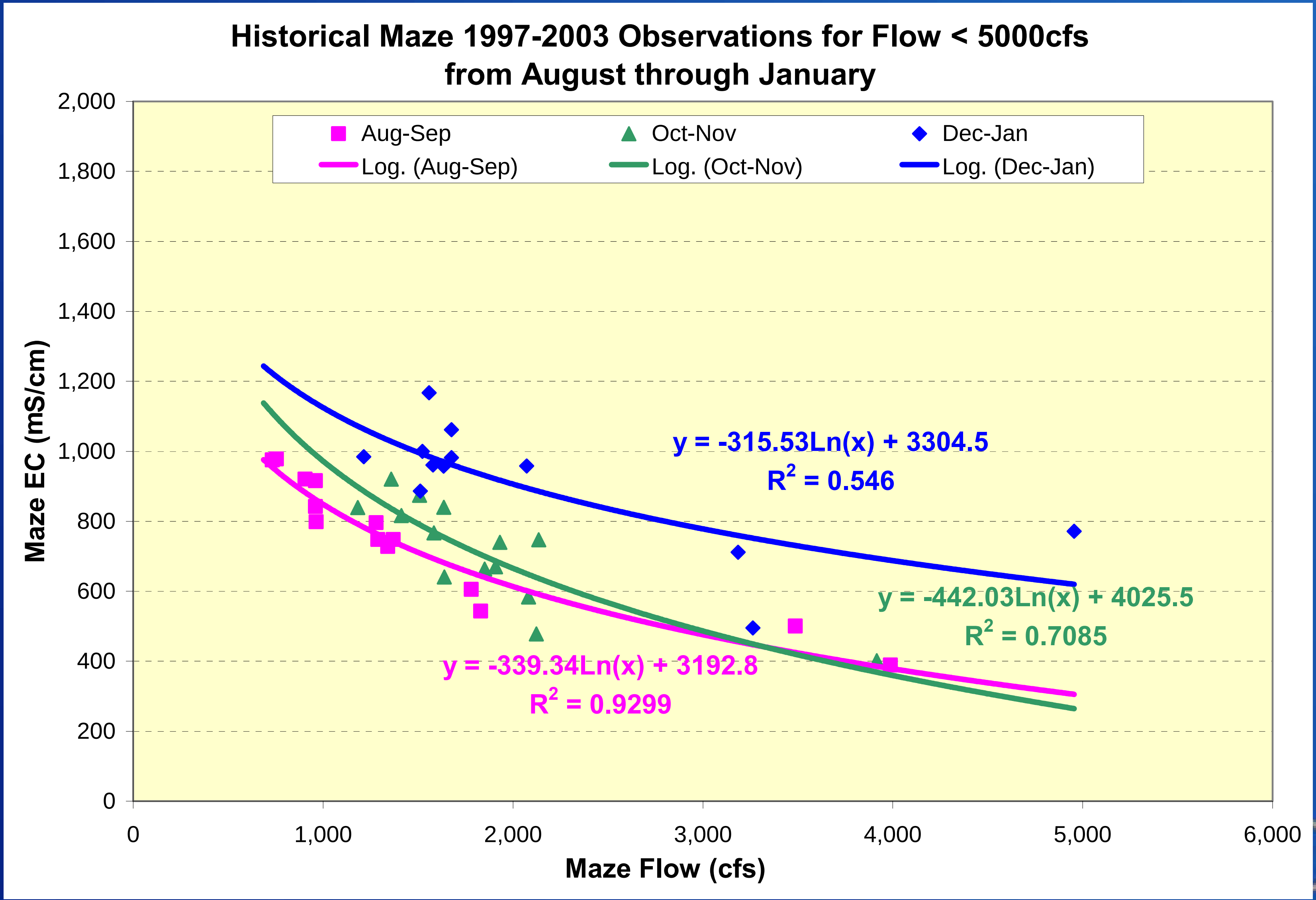
WQM Calibration
EC-Flow Rating Curves: Newman

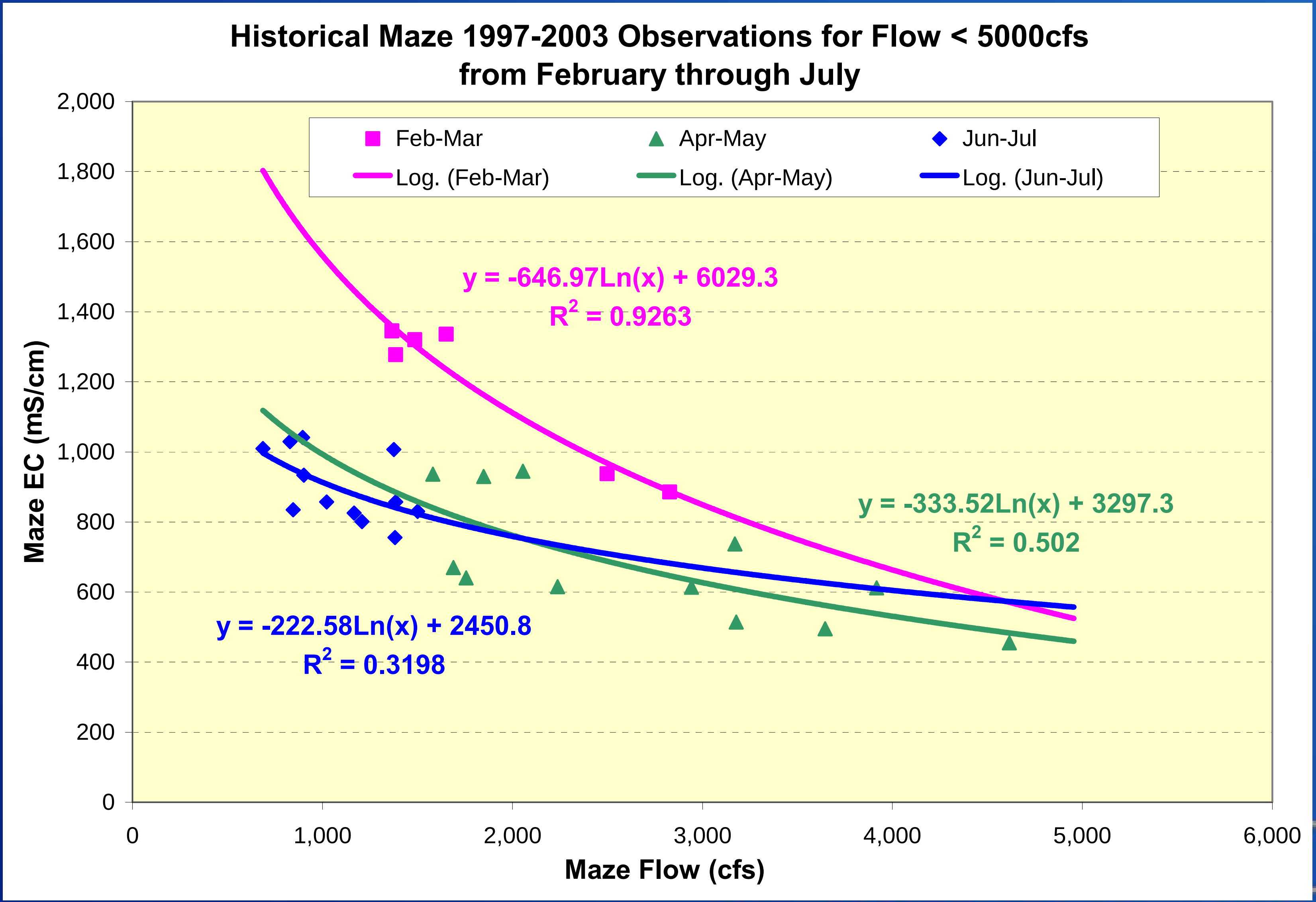


WQM Calibration

EC-Flow Rating Curves: Maze



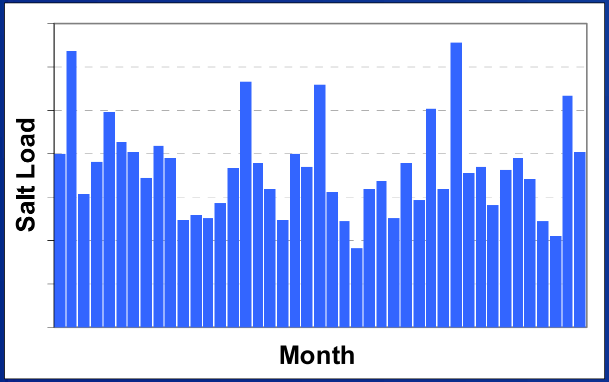
WQM Calibration
EC-Flow Rating Curves: Maze (continued)

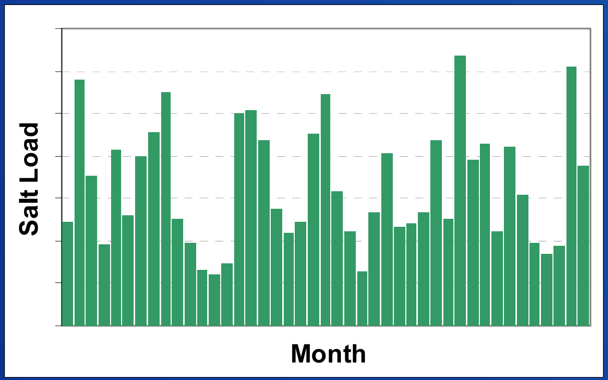


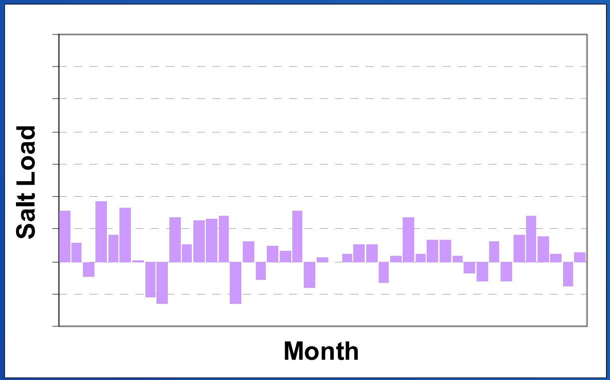
Detailed Process of Calibration 2 (continued)

2. Each month, obtain the salt load target at the gage through the regression equation in Step 1. Calculate the total salt load from non-local creek flows within the river reach. Subtract the latter from the former to obtain the salt load residual.

Salt load target at gage - Salt load from non-local creek inflows = Salt load residual





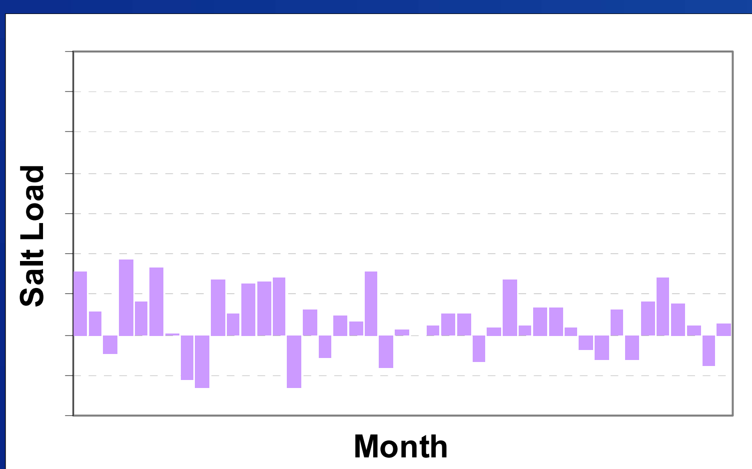


Local Creek Inflow Water Quality (Calibration Procedures)

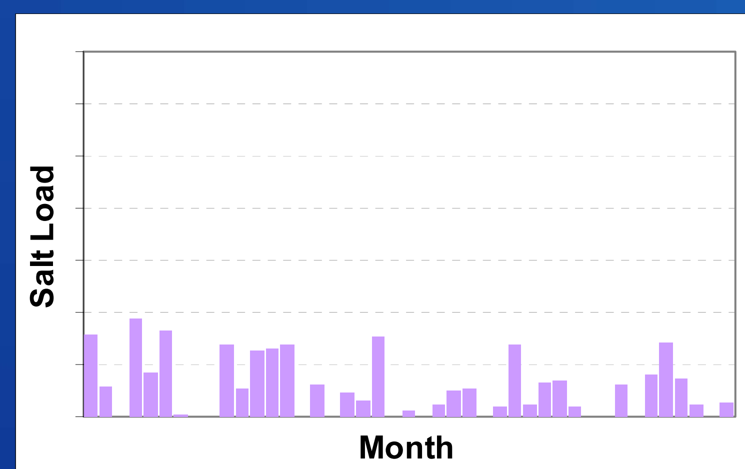
3. Reset the negative salt load residual to zero. This load residual time-series becomes the input of Water Quality Module.

Note: Negative residuals do not occur during months with simulated New Melones water quality release.

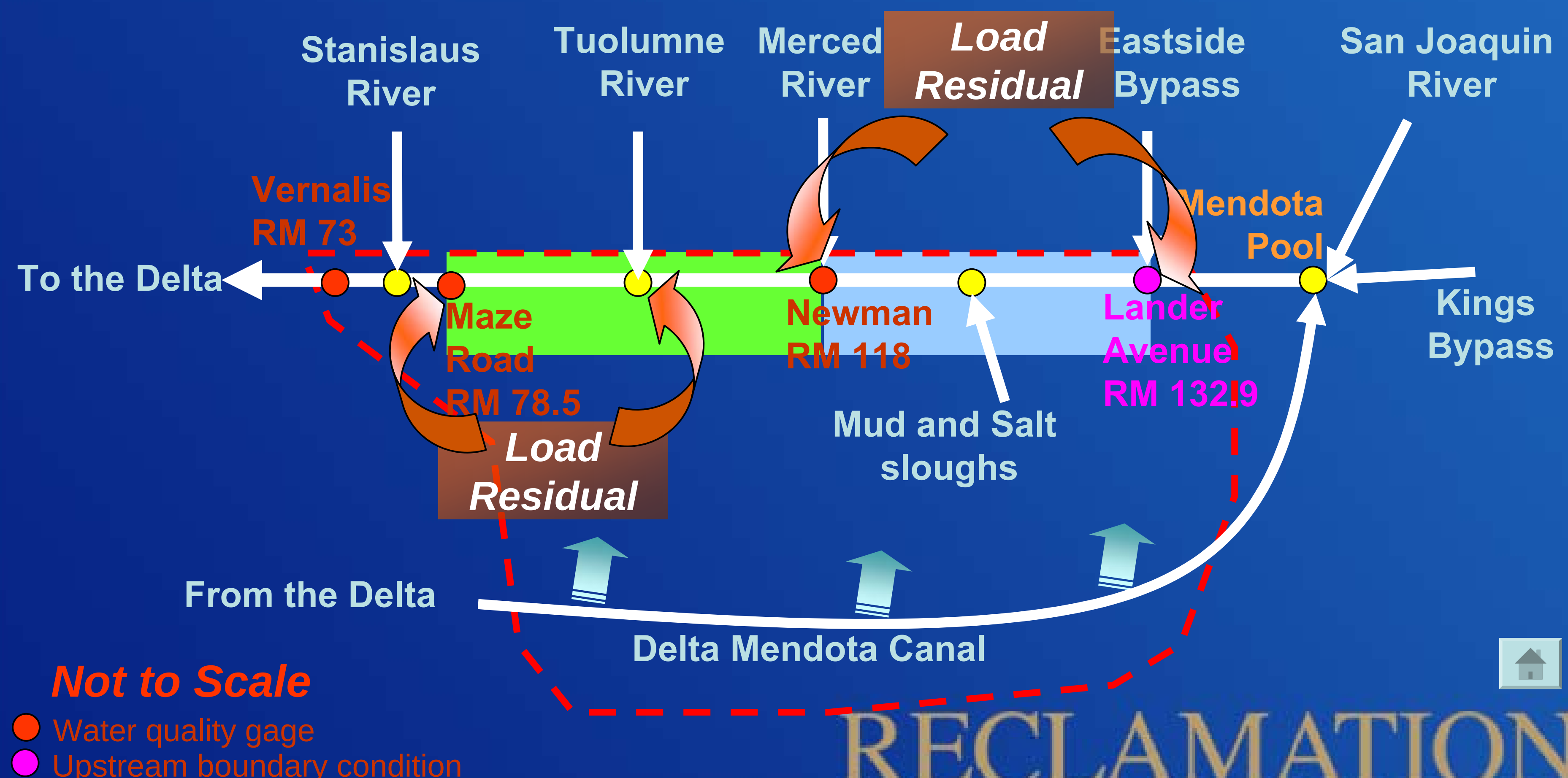
Calculated salt load residual



Reset load residual time-series as Water Quality Module input



Allocations of Load Residual



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Non-Project Returns	SJRIO (2003 version)
Within Accretions	
Tile drainage	SJRIO (2003 version)
Base flow	SJRIO (2003 version)
Local Creek Inflows	***Residual term: EC-flow relationship***

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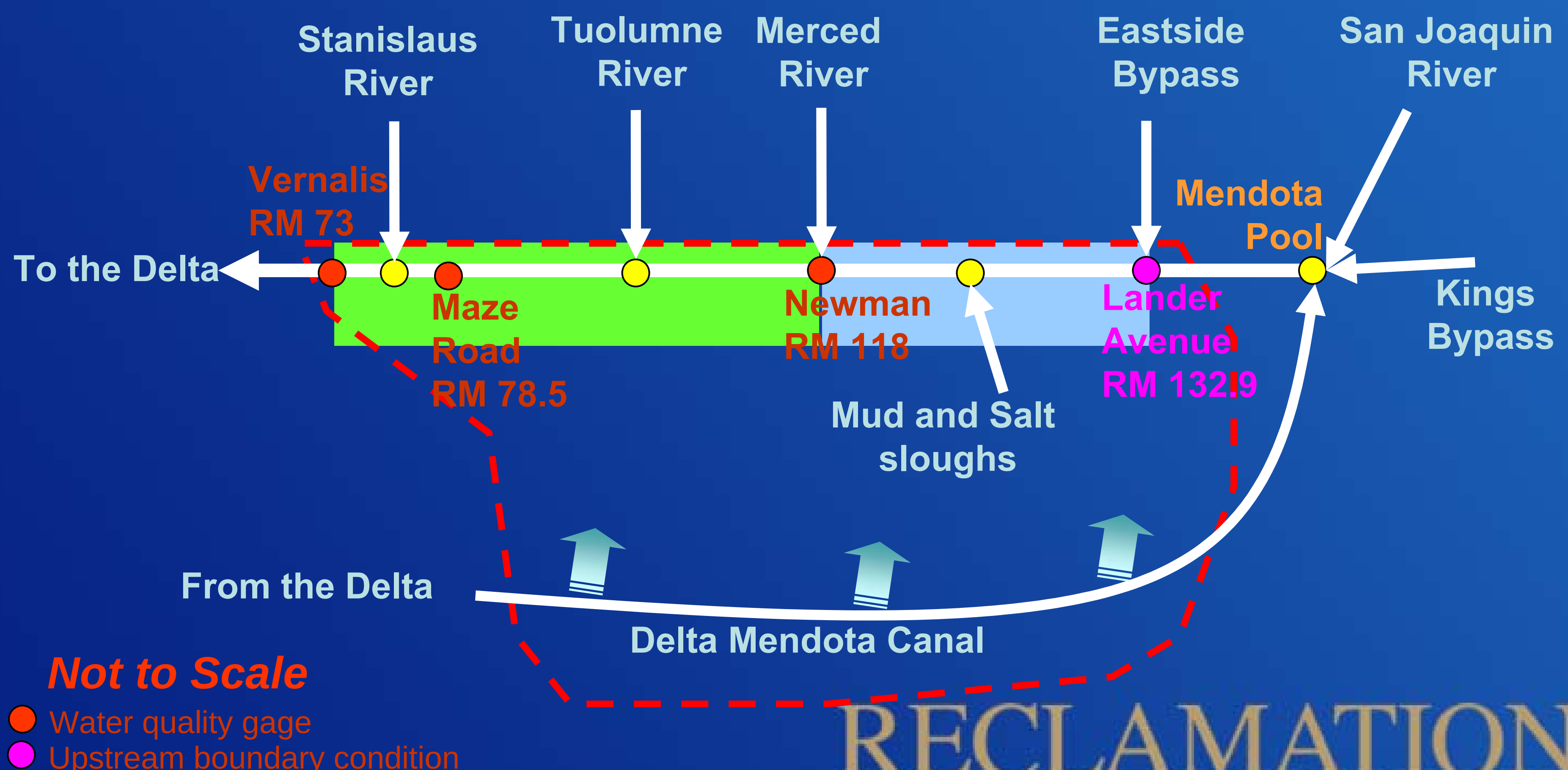
Calibration Reaches

- Consistent with reaches for hydrology development
- Choosing gage with more available data



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Summary of Calibration

- Residual term: EC for local creek inflow
  - Reasoning: matching closure term in flow disaggregation; no water quality information available
  - Assumptions:
    - Exponential relationship between flow and EC
    - Parameter estimation by calibrating against historical records
  - Results:
    - Monthly relationships were developed
    - Simulated operations deviate from recent experiences in New Melones operation in some months
  - Possible causes:
    - Several … requiring more detailed investigation

New data emerged – Maze and Newman gage records

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